School Science

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ASSOCIATIONS OF SCIENCE TEACHERS.

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Regarding the value of such gatherings as are implied in the subject of this paper, there can be no doubt. It is high time that all teachers of natural science should turn their attention, more seriously than ever, to the growing material available for use in secondary schools and colleges and to better methods of imparting this material to our students, and especially to the secret of kindling their enthusiasm in some one or more of the live, practical helpful disciplines, now offered so abundantly in most good curricula.

And, firstly, get together. A call for a special branch meeting at the same time and place of the regular county or state association, is a feasible plan for a start. Two or three of the more prominent teachers of natural science can well issue the call,—by private letters, by formally printed circulars, or by open advertisement in school journals. But see to it that all teachers interested by reason of their work, their location, or their influence, are included. The Colorado association was suggested by half-a-hundred private letters sent out by a teacher in the State University, on his own responsibility, and the call met with a hearty and unanimous response. The teachers gathered and organized as a branch of the state association, but free to hold meetings at other times and places, as desired, as a quasi-independent society. Be sure to keep close to the main local association, which should represent the unified work of the best in the respective region. Even in the new organization, not disintegration, but union should be the motto. Moreover, there are many related questions which

cannot be settled in the natural science department alone, but which require coöperation. Also be sure and secure at least the tacit encouragement of all principals and superintendents. We shall need all their intelligent sympathy and assistance long before we succeed in attaining the many desirable improvements that will come up from time to time for adoption.

Regarding the machinery of organization, nothing need be said in detail; but keep it all simple; trust each other and do not hamper the possibilities of good work by unnecessary red tape. Let a few responsible, capable and progressive people, as officers, direct the affairs, each in turn for a year. Be wisely generous and foresighted in allowing all subjects, institutions, and sections of country, each a fair representation. Keep down clique; keep up the interest in the main topic—the study and teaching of natural science.

I believe it is a fact of history that the Division of Natural Science Teaching in the National Educational Association (N. E. A.),—as also that which is now the State Association of Natural Science Teachers of New York,—was organized by influences radiating directly from the Colorado organization. In the case of New York, it was this way: The next pending meeting of the N. E. A. was to be held in Buffalo. The secretary of this department in the N. E. A.—who was also an organizer and officer of the Colorado association—wrote to the Buffalo people, asking to be placed in touch with the officers of the state association of New York. The answer came back that there was no such association in existence. The suggestion was made to the Buffalo people that they should use their natural science meeting in the N. E. A., as the occasion and nucleus for the organization of such an association in the state of New York. The suggestion was at once acted upon by the energetic teachers of natural science in Buffalo, and circulars were sent out all over that great state, asking all teachers interested in the project, to gather at Buffalo. At the appointed time, Professor Bessey, of Nebraska, then the president of the Division of Natural Science Teaching of the N. E. A., with others, met the assembled delegates. President Schurman and Professor Gage, of Cornell, were present, and started the ball rolling by their hearty approval; and the latter was

elected president of the newly organized State Association of Natural Science Teachers of New York. Under such auspices and with such management at its head, it naturally assumed at once its proper sphere, and from all that the writer can learn, is still alive and doing a vast piece of work.

For the special program after organization, probably most of the papers will bear on the system and methods followed by the readers of each respective paper. The implied discussion, modification, and adoption of all this will bear obviously valuable fruit. But it may be well to note some of the special subjects for work that the Colorado Association has followed, that being the one with which the writer is best acquainted.

The State University and some other colleges in Colorado had been recommending a preparatory course in natural science, as follows, viz., one year each in physics, chemistry, and biology, and in this order. Of course, there was to be required the implied laboratory method and equipment for each science. The State Association of Natural Science Teachers took up the discussion of the desirable order of science studies, and, on account of the close dependence of physics on mathematics, recommended that physics be deferred till one of the last two years of the preparatory course. This gave that subject some advantage, and led to some specialization therein,—not necessarily undesirable even for the preparatory course, as we recall the magnificent specialization in Latin, Greek, and mathematics which has been not only allowed but demanded for scores of years in all our good high and preparatory schools.

And thus there came to the front as an ideal, the necessity of some sort of specialization in each science,—and the idea is quite likely to remain prominent for some time. Other topics were found in papers—many of them long, exhaustive, and valuable—on the year, the time spent in recitation and laboratory, the books, the methods, etc., for each subject, physics, chemistry, and biology, and sometimes for the related though less fundamental subjects of physical geography, astronomy, and geology. These papers often included reports, collated from hundreds of the larger high and preparatory schools all over the country. In general they all indicated improvement as compared with former times, but seemed

to leave much more to be done in the way of enlarging the scope and improving the discipline.

Perhaps the pleasantest influence connected with these gatherings is the new and warm friendships formed—the writer can speak with great feeling on this point—as also the stimulus that each received to go on and master both the subject matter and also the methods of his particular science.

But organization means life only when it is doing something for somebody else; and these science teachers' associations will find their true significance and value just in proportion as they shall apply themselves to see what the problems are, and then plan a long, patient, dogged course of attack. It is fairly easy to see what ought to be done; it is harder to see what may be done; still harder is it to see just how it must be done. But hardest of all is to see all this, and yet be obliged to wait for years, perchance, till certain changes may come about allowing the bare possibility of new improvements. But this is what many of us must do, and what we are going to have the determination to do, before we will ever relax our constant interest and endeavor.

Among the thoughts which I would suggest for my many colleagues are these:—

Firstly,—is there any one science which is fundamental to and underlying all the others?

Secondly,—if there is such a fundamental science, what is it? and how shall we group the others about this in logical and fruitful coördination?

Can we arrange a course of science which may some day compete, in thoroughness and finish of discipline, with the old reliable Greek, and Latin, and mathematics, and still be fully and truly natural science—really "natural," progressive, fascinating, and productive,—not invidious of the classics and humanities, but recognizing their mutual interdependence and separate value?

I believe that all this can be done, and that it will be greatly promoted by the organization of associations of teachers of natural science.

School Science

HIGH SCHOOL ASTRONOMY.

BY GEORGE W. MYERS,
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INTRODUCTORY.

All science teachers, save those of astronomy, agree that beginning students should be given an extended acquaintance with the facts and more obvious uniformities of nature before having much to do with the theories underlying their explanation. Even teachers of astronomy admit that this is the only rational *modus operandi* for other physical sciences than their own. While not disposed to contest the general principle that laboratory, or observational, methods furnish the only sound mode of approaching the study of the truths of nature, most astronomical teachers, and especially high school teachers, see practical difficulties in the way of applying this principle which have hitherto proved prohibitory. As a result, most teachers of astronomy are still clinging to the text-book method of teaching with a devotion worthy a better cause, in the face of the admitted fact that this method has long been relegated to the limbo of the antiquated in all branches of science allied to astronomy.

Instances are known in which the same teacher who planned and executed an admirable preliminary experimental course with his high school class in physics, introduced the same class to the truths of astronomy by the text-book exclusively. Is it not amazing that these things should be so, when we remember that the "wonderful century" just closed, owes the unparalleled advance it has made, at least so far as relates to education, more to the wide-spread introduction of what we have come to know as the scientific method into school work than to all other agencies combined? On the firm basis of this method, discovery and invention have come to be the rule rather than the exception with us. Through it we have learned the true point of vantage for attacking the strongholds of the unknown.

Before the nineteenth century had entered upon its marvelous career astronomers had proved to the world the great fertility of this method for the investigator. It remained to this century

to demonstrate that the method of the investigator is also the method for both teacher and pupil that it is, in short, the method of teaching. How fully and nobly she has performed her task can be judged from the all-pervading prevalence of the scientific spirit of our time.

In the light of these unquestioned facts it is little short of astounding that teachers of elementary astronomy, the oldest, noblest and the most pre-eminently observational of all the sciences, should have responded so feebly to the quickening spirit of the laboratory and observatory. It would seem that after the great astronomical teachers of the pre-nineteenth century had shown the world the true method of teaching, their successors, Esau-like, had renounced their birthright. The few paragraphs which remain to this paper will undertake to discern why this occurred and to suggest a few reasons why modern teachers of the elements of astronomy should return to their inheritance.

It has been but a few decades since astronomy came to be recognized as a proper subject of study for the masses of the people. This was due to a two-fold cause. The wide prevalence among the people of superstitions and of the belief that the subject was suited only to princes, gentlemen of leisure and to the intellectually gifted who were favored with princely patronage, combined to isolate it from the people and from schools. The company the subject had so long kept among astrologers and the nobility even prejudiced the popular mind against it.

The elaborateness displayed by these exalted personages in the erection and equipping of their observatories and the failure of all to recognize the practical utility of the science for work-a-day folk served to content the popular mind that the subject should remain apart from their concerns. The superstitions connected with astrological practices were long cherished by the people and encouraged by quack astronomers, after they ceased to awaken the belief of the educated part of humanity, and these practices fettered the minds of the masses with the indisposition to inquire. Add to this the fact that astronomy was so inextricably interwoven with astrology for centuries as to render the task of ascertaining what was the truth and what error almost hopeless to any but the initiated few, who had no desire to make the distinction.

Again, astronomy, having its beginnings in astrology and in the minds of the people being identified with it, was in their opinion bound to verify the extravagant predictions of the pseudo-science. Failing in this, the real science fell into discredit, so that after the other physical sciences had established the reliability of their conclusions and predictions, they were naturally looked upon as worthier of recognition in educational systems. Those scientists who did succeed in mastering the principles of astronomy and in gaining access to observatory equipment, soon became so engrossed in the beauties and wonders of the sky that they chose to give their thought and time to the pursuit of new truth rather than to popularizing the old. Consequently, they troubled themselves little with popular prejudices against the science.

Finally, a practical acquaintance with astronomy can be attained only by those well versed in the higher mathematics and mechanics. Failing to distinguish between the degree of mathematical attainment needed for making discoveries and what is requisite for understanding what others have done, most persons, appalled by imaginary difficulties, shrink from the supposed task of attempting to acquaint themselves with the elementary truths of astronomy.

However much, or little, reason there may have been in these arguments a hundred years ago, they can have no force with us to-day. Experience and study have taught us the distinction between the superstitions of astrology and the verifiable acts of science. The only remnants of the pseudo-science which remain with us are a term here and there, and we no longer look up on the tenets of astrology as dogmas of authority. Of late years astronomical advance has been so rapid and so suggestive and the dissemination of knowledge so general that the people recognize both its practical and its intellectual value. In response to the demand of educational thinkers and school managers that the study of astronomy shall be approached as is the study of its kindred sciences by observational work, not a little has been done by Prof. Todd, of Amherst, in his "New Astronomy," and by Miss Byrd in her Laboratory Manual. But so long as the suggestions of these writers remain as printed matter in a text-book they are useless. These suggestions must be put into practical application by astro-

nomical teachers before they can bear fruit. In the later issues of SCHOOL SCIENCE it will be shown that much observational work may be done and much inexpensive apparatus may be devised for experimental work with the stars, and that the old idea that practical astronomical work can be carried on only with the aid of an expensive equipment is wrong.

METROLOGY.*

A FOREWORD.

The Department of Metrology will devote itself in general to metric reform in its broadest sense. Especially will it advocate the adoption and use of the metric system of weights and measures. The schools are wasting many years in teaching a system, or a conglomeration of systems, the parts of which have no connection and are a relic of semi-civilization. Outside of science teaching and scientific research there is no harmony between the notation scale and tables of measures. We add, subtract, multiply and divide in tens; we weigh, measure and compute by 12, 3, 16, 272¼ and many other unrelated numbers.

While the accuracy of instruments of measurement and weight is now greater than it was a century ago, the system and the tables are as clumsy as they were then. We are still content to use a vehicle which a majority of the nations long ago discarded as unfit for use, though the centennial of the new system was passed last year in France.

There is no periodical with a department for metric reform. One struggling organization holds occasional meetings for the promotion of the cause. Possibly a half dozen associations have metric committees. An article now and then in a scientific periodical, or an editorial in some prominent daily, usually favors the metric system. A committee on coinage, weights and measures in

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*All communications for the Department of Metrology should be sent to Rufus P. Williams, Cambridge, Mass.

Congress is committed to the reform. It reports favorably at each Congress—and there the matter ends.

There is little opposition, but very much apathy. Those who do not know the metric system are legion. Even among scientists who employ it most exclusively, there is much ignorance outside their special field. The chemist who knows milligrams and liters as he knows his own name has but a vague idea of hectares and steres.

The object of this department in SCHOOL SCIENCE may be classed as threefold: 1, Historical; 2, Scientific; 3, Promotive. A series of historical articles will deal with numbers and notation; measures, weights and coinage; chronology, the calendar, circular and other measures, etc. The development and growth of the international system will occupy the foremost place—the history of its adoption, the laws and the progress of legislation in the various countries being a feature, as well as the efforts made to adopt it in the United States, the extent to which it is taught in public schools, its use by manufacturers and individuals, and state laws regarding weights and measures.

In the second or scientific division will be shown the superiority of the metric over the old systems: the great waste of money, time and energy in the use of the latter; and the bearing of the subject on trade and foreign commerce. Books and magazine articles on various branches of metrology will be reviewed, and the columns will be open for discussion of any point.

To promote a healthy, zealous sentiment in favor of metric reform is the third and main object—to awaken a widespread interest in the matter, so that believers in the system all over the country may work unitedly and earnestly for metric reform. A well known educator lately remarked: "I think it a shame that all scientific societies do not unite in a solid movement in favor of the metric system." Chemists and physicists know better than any one else the saving by a general use of the system, for they employ no other, except as they are forced to do so. It is absurd to suppose that any chemist would revert to the old system. But the business man, the trader, the manufacturer, the exporter, in short, the man who does any weighing or measuring would experience a similar advantage from the use of the metric measures.

No case is on record of a nation which has employed this system desiring to go back to its former one.

The use of international weights and measures has gone about as far as it is likely to go in this country without further legislation. In isolated instances manufacturers employ it, but even then they must buy and sell by the English measures, thus making double work of changing from one to the other. To the exporting manufacturer the question is becoming a serious one, for—aside from Great Britain, Russia, Denwark and China—he must sell in metric countries and compete with metric manufacturers. Repeatedly it has been shown by consuls from almost every metric country that estimates given in English measurements are thrown out in favor of those in metric figures. Thus the battle is likely to be transferred from the field of science to that of business.

To the accomplishment of the ends outlined above, the editor of this department asks the coöperation and assistance of all persons interested in the science of metrology—with whom correspondence is solicited—and welcomes any facts bearing upon the subject in its various aspects. SCHOOL SCIENCE is the only organ and exponent in this country of the metric system.

RESEARCH WORK FOR PHYSICS TEACHERS.*

BY PROF. E. L. NICHOLS, CORNELL UNIVERSITY.

The teaching of Physics is in itself a delightful thing, but to be thoroughly enjoyed it should be seasoned with research. Nearly 90 per cent of the scientific work of the world has been done by teachers. But, important as the achievement of the teaching class has been in research, comparatively few of those engaged in the teaching of physics can be counted as belonging to the ranks of the investigator. The principal excuse offered for scientific unproductiveness are lack of time, lack of apparatus, and lack of the

*An abstract of a paper read before the Physics Club of New York, December 8, 1900.

necessary qualifications for the work. The difference between college teachers and teachers in the secondary schools in these respects is much smaller than commonly supposed. Both are overworked, but it is equally possible for both to find time and opportunity for investigation. The real explanation of the unproductiveness of secondary school teachers lies in absence of the habit of investigation, a habit that, like all others, must be acquired by continued practice. Given a well developed habit of experimentation so that a fair knowledge of what has already been done exists, it only remains to select some topic and to study that persistently until definite results have been obtained. While all subjects for investigation are not within the easy range of the teacher in the secondary schools, the list of those available is a large one. It includes among others the study of the influence of absorbed gases and salts or the admixture of liquids, such as alcohol or sulphuric acid, upon the point of maximum density of water; the density and coefficient of expansion of liquids having low freezing points; the verification of the law, already theoretically established, by van der Waals, of the relation of the expansion of liquids to their critical temperatures; the completion of our very imperfect knowledge of specific heats at low temperatures; the determination, in the case of substances not yet experimentally investigated, of the precise value of Poisson's ratio; the study of the temperatures of the flames of burning alcohol and of ether and of carbon disulphide; the systematic investigation of the action of light and of the x-rays on previously exposed plates and the application of the photographic method to various problems in physics, such as photography of absorption spectra in the infra-red.

In this list is mentioned only a few of the innumerable topics available for physics teachers. It is a characteristic of our science that every contribution brings with it a group of further problems to be solved. One cannot read any memoir intelligently without perceiving the possibility of extending the investigation further. Given the desire for research, which is the inevitable result of the habit of experimentation in every one whose mind is fit for scientific pursuits, and the difficulties of time, opportunity, and equipment can be overcome.

The proper stimulus for scientific work is the love of experi-

mentation for its own sake, rather than any desire or expectation of fame; the delight of witnessing the wonderful performance of matter under conditions conceived and imposed by ourselves rather than the hope of achieving some momentous result. At the same time we should not forget that the very simplest phenomenon of nature is worthy of our reverent attention, and that an experiment seemingly unimportant may ultimately be of inestimable value to science.

QUANTITATIVE EXPERIMENTS IN CHEMISTRY FOR HIGH SCHOOLS.

BY LYMAN C. NEWELL, Ph.D.
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Opinions differ widely regarding the nature of the experiments which should constitute a course in chemistry for beginners. There is a growing belief, however, that a course covering the usual time should include some experiments which involve accurate weighing and measuring.

No teacher in chemistry can truthfully deny the fundamental value of exact work. Granting the desirability of acquiring general information, of developing manipulative skill, of interpreting experimental data, and of recording notes in concise English, the problem of effective laboratory work still has another essential factor. Many teachers feel keenly that their pupils often place little confidence in results which are merely observed, that they have a minimum respect for exactness, and that they are contented to do perfunctory work as long as such a performance meets the requirements,—personal or what not. In a word, experiments to be fruitful must contain some feature which will require the pupil to test the accuracy of his own experimental work. This essential is often satisfactorily secured by utilizing judicous questions or by employing confirmatory tests. Such plans, however, demand considerable time, and in some cases actually increase the pupil's mental confusion. The simplest and

most profitable way for the pupil to attain accuracy of head and hand is by the performance of some experiments which rigorously but agreeably demand continuous thought, skill, patience, and judgment. Such experiments are popularly called quantitative.

By quantitative experiments we do not mean "research work," nor the simpler determinations which are included in the customary course in quantitative analysis in colleges. Such work cannot be transferred bodily to a high school. It is just here that some teachers and authors have made a fatal mistake, and they are partly responsible for the negative attitude assumed by some secondary teachers toward exact work. Quantitative experiments intended for beginners should possess those elements which characterize all profitable experiments. For example, they should demand only the average degree of manipulative skill. Skill comes by constant, protracted labor. It is an evolutionary product, and is not possessed by beginners. These very experiments teach skill, and hence we should not assume what we are to teach. Again, quantitative experiments should be simple, but they should yield results which will not shake the pupil's confidence in the possibilities and value of exact work. In other words, the apparatus and methods employed should yield numerical results which are approximately accurate or at least concordant. Indifferent results usually produce indifferent interest. The adolescent mind finds no pleasure in contemplating the "error due to some unknown cause." The beginner has not the spirit of investigation. Furthermore, quantitative experiments must fit the course. They should not require too much individual time and attention, partly because time is not usually available and partly because protracted attention is apt to dull interest and thereby defeat the attainment of one inestimable pedagogical goal, viz., voluntary attention. Nor should such experiments call for complicated, fragile, or expensive apparatus, even though such a sacrifice introduces a small but known, constant error into the final result.

The question of apparatus is doubtless the most serious objection to the introduction of much quantitative work into high schools. An experience of several years indicate, however, that this objection is by no means insurmountable, provided certain principles prevail in procuring apparatus. All the quantitative

work need not be installed at once. Begin with experiments which require apparatus largely in stock, such as large bottles, tubing, stoppers, large scales. Such apparatus accumulates, and if forethought prevails, enough apparatus may be collected in a short time to permit the performance of several experiments. Again, it has proved prudent to buy each year a few pieces of apparatus which are for general use, e. g., accurate balances, weights, graduated tubes, crucibles, hard glass tubing, burettes. This apparatus is not expensive, if the availability is divided by the cost. Judicious selection, likewise, saves money. A thrifty teacher once said: "Count the cost *before* the bill is rendered." A balance or set of weights that will last for years, is worth more than one piece of fragile apparatus for the lecture table, however handsome the latter may be. One balance at ten dollars is not so serviceable as three horn-pan balances, if only ten dollars are available. If the horn-pan balance is encased in a properly constructed box* to protect it from drafts, it will weigh nearly as accurately as the more expensive balance and permit three times the amount of work. Finally, money and time may be saved by performing experiments which utilize a typical apparatus, or one having interchangeable parts. Thus the equivalent of three metals, zinc, magnesium, and aluminum, may be determined by using a apparatus consisting of a small flask, thistle tube, delivery tube, and graduate tube. The same flask may be used in any other experiment demanding one of that approximate capacity, and the graduate tube may be repeatedly used in experiments involving gas measurements, e. g., the determination of the composition of air, hydrochloric acid gas, and ammonia gas. A large bottle (five-pint acid or lithia bottle) may be used advantageously in many different experiments; e. g., in determining the weights of a liter of oxygen or of air, as an aspirator, as a reservoir for water or gas, or as a large generator (for hydrogen, carbon dioxide, and hydrogen sulphide). Considerable expense may also be saved by using apparatus adapted to the same sized rubber stopper. Thus a rubber stopper which is 23 mm. in diameter (smaller end) will usually fit a 500 cc. Florence flask, a 250 cc. Erlenmeyer flask, a

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*See Newell's Experimental Chemistry, page 347.

large test tube (8 in. by 1 in.), and a five-pint acid bottle. It is the candid opinion of the writer that expense need not deter a teacher from doing quantitative work in chemistry with his class.

The fundamental aim in utilizing quantitative experiments should be to teach the pupil accuracy, confidence, cleanliness, and a profound regard for exact experimental work. This aim may be accomplished by careful, patient, sympathetic, inspiring supervision of each pupil's work. Such teaching takes time, but no more time than any good teaching. Indeed, as soon as the pupil has learned to weigh, a few preliminary directions or words of caution at a critical point are sufficient, unless the pupil is a born blunderer. The writer makes an especial effort to prevent unfortunate accidents or mistakes due to a large personal equation, which might necessitate the tedious repetition of an experiment. Thus weighings and readings are frequently verified, legitimate sources of error are indicated before the apparatus is taken apart, residues are saved until the final test is calculated. This critical supervision, which is thoroughly legitimate and exceedingly essential with awkward, careless beginners, saves much time and annoyance, and permits thereby the performance of many experiments not necessarily quantitative, which could not otherwise be included in the regular course.

Quantitative experiments should be interpreted from the same standpoint as that adopted in other experiments. The object is to do the experiment as well as possible, not to secure by hook or crook an answer which is theoretically correct, or which pleases the teacher, or which is "better than he got," or which usually agrees with some book. The writer accepts results which are the outcome of reasonably good work, whatever their mathematical value may be. A complete record of each pupil's work is kept, and if improvement is shown, the pupil is ranked accordingly, even though his [illegible]nerical answers may be somewhat discordant. As a matter of [illegible], the pupil volunteers to repeat the experiment if the result is erroneous, especially if he knows the source of error and is encouraged to believe that he can avoid this error. Such additional work, however, is usually done outside of the regular laboratory period. Again, the teacher in interpreting quantitative experiments should demand no better results than the apparatus

and method permit. To insist on theoretical results is downright absurdity. As a matter of fact, working conditions (barring the personal element) always determines the value of a final result. An analytical chemist does not strive to get "the theory." He aims to get the most accurate result consistent with working conditions.

For the benefit of those who are skeptical about the results obtained by beginners in quantitative work, the writer cheerfully records here some averages taken from a summary of work done by his classes. It should be said in passing that many teachers who are using the same experiments report results just as uniform and accurate: In determining the percentage of oxygen in potassium chlorate, the average of 23 results was 39.09 per cent; the lowest of these was 38 per cent., the highest was 41.33 per cent, but only three were above 39.04 per cent. In many instances the latter part of this experiment was performed simultaneously with other (simpler) experiments. In finding the ratio in which magnesium and oxygen combine, the average of 27 results was 1.52. In finding the weight of a liter of oxygen, the average of 24 results was 1.449 grams; of these results, the two lowest were 1.40 and 1.44, the two highest were 1.46 and 1.49. In a similar class of more patient pupils, the average of 8 results was 1.43. In finding the equivalent of zinc, the average of 19 results was 32.43, of 25 results was 32.30. The result in the latter series varied from 31.5 to 33.0. The average of 23 determinations of the water of crystallization in barium chloride was 14.88 per cent; half of these results were between 14.66 and 15.00, and none was above 15.00. The average of 21 (another set) was 14.71 per cent; only three of these were above 15.00 and 11 were exactly 15.00. The experiment followed the three above mentioned and the results demonstrated undeniably the acquisition of skill, patience, and care. This experiment, as in the case of the determination of oxygen in potassium chlorate, once started, was allowed to "run itself" while the pupil performed other experiments. The average of 22 determinations of the oxygen in air was 20.64 per cent; and of 39 determinations was 20.97 per cent. This experiment involves considerable care, but is exceptionally instructive.

The results were uniform, though often somewhat low owing to the difficulty of removing the last traces of oxygen.

The manner of conducting laboratory work of a class performing quantitative experiments varies with the conditions. If the divisions are small, the experiments can be done by each pupil, but if the divisions contain fifteen or more, it may be necessary for two pupils to work together. Some experiments are admirably adapted to the latter procedure. In such cases, it is advisable to require each pupil to calculate the results independently. Considerable time may be saved by allowing the calculation to be made outside of the laboratory, especially if the operation has become so familiar that accuracy is the only essential. Many teachers do not permit pupils to read the barometer, and the writer has a growing belief that such a prohibition is prudent. A reading taken by the teacher and posted in plain sight will be sufficiently accurate for the laboratory period. Considerable annoyance and delay may be avoided, if general conditions are carefully and regularly scrutinized by the teacher. If gases are to be measured over water, the water must be kept standing in the laboratory long enough to allow it to assume the temperature of the laboratory, and if its temperature is to be determined, as is often the case, the same thermometer should be used for successive determinations. A few trials will reveal the best location for work with gases, e. g., out of the direct sunlight or away from hot air drafts. Beginners are apt to estimate weights and readings. Such a fault needs immediate and unequivocal discouragement. Pupils soon detect which way to estimate and some have little compunction against manipulating data, especially if the experiment has an excessively large disciplinary element. Beginners should be taught to accept the truth, whether such acceptance is agreeable or not. It is advisable for the teacher to make enough preliminary trials of an experiment to determine the limits of error. Such a precaution will reveal what results to accept. With some classes, especially mature pupils who look forward to advanced work in science, these preliminary trials provide a fruitful opportunity for investigation. Let them discover the errors in the method or the defects in the apparatus. Many a pupil discovers himself in such work—a most profitable discovery.

Quantitative experiments in chemistry furnish an attractive basis for the discussion of chemical theory. It brings the beginner face to face with the harmony and unity of nature. He sees the truth and realizes that the outer truth is recognized only by a consciousness of inward truth, for "that only which is within can we see without."

A TEACHER'S INDEX OF CURRENT PHYSICAL LITERATURE.

BY GEORGE FLOWERS STRADLING.

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For three years the writer has kept an index of those parts of the literature of physics which he has desired to retain within mental reach. To him the result has grown to be of so much importance and help that he takes this opportunity of describing his method to his colleagues.

The outfit consists of a bookkeeping journal of 600 pages, of a lettered index, and of a letter-file, the respective prices of which are about 60, 25 and 30 cents.

Under the letter A of the index, the following is a part of what is found:

24.—Alloys.
11.—Action at a distance.
53.—Atmospheric electricity 460.
218.—Atmospheric pressure.

The number 24 before the word "Alloys" refers to the page in the journal which has this word as heading. On this page are more than a dozen references. The first is Roberts-Austen: On Alloys. Important. N. 2, 18, 377, '97. Thus I learn that on page 377 of the copy of "Nature" for Feb. 18, 1897, is a good article by the eminent authority whose name is given. Following the above are references to

Application of x-rays to study of Alloys.
Freezing Point Curves of Alloys of Zinc.

Micro-structure of Alloys.

Heat of Formation of Alloys.

The periodicals cited are "Nature," "Philosophical Magazine," "Electrical World and Engineer," "Chemical News" and "Proceedings of the Royal Society."

The index contains altogether more than 160 different scientific headings, almost exclusively physical in character. This list grows quite rapidly. The work done by J. J. Thomson and the Cambridge physicists on the conduction of electricity through gases by ions led recently to a new title, Ions.

When, in looking through a periodical, I see an article or paragraph that seems to have permanent value, I enter it on the front page of the journal, and thus by the expenditure of no great amount of time, I come to have a list of the newest articles treating of the subjects in which I am chiefly interested. When a lecture is to be prepared, I have ready at hand a list of references which will put me in possession of what is most recent on the subject. When I want to have my students learn something of the value of periodical electrical literature, I turn to the index and find both subjects and material for essays. In addition to these objective advantages, there is the subjective one that I feel a satisfaction in the confidence that when I read a good thing, it is not allowed to drop from sight, but is written down where it can be readily found.

The letter-file is used to hold clippings. These are indexed just as articles in magazines are, the location reference giving the letters of the file where they are kept.

In these days when the card catalog is pre-eminent, no doubt any one who reads what I have written, if he does me the honor to reflect at all, will wonder why I did not adopt a card catalog. The reason is that I found my plan to be far the cheaper. Besides a page has the advantage of *Uebersichtlichkeit* in comparison with a row of cards, and the index has occasionally to be carried to school.

The forming of the index has been a stimulus to me. I now index about twenty-five or thirty of the chief physical journals, and feel a certain modest pride that nothing of great value that is published escapes being set down in the index.

THE TEACHING OF PHYSICAL GEOGRAPHY.

BY WM. H. SNYDER.
Master in Science, Worcester (Mass.) Academy.

What is physical geography? The best definition is, the study of the relation of the earth to man. What does this mean? It is not a study of the structure, compositions, motions, activities or surface conditions to simply find out why they are what they are, but it is the study of their action and development upon the life and industries of man. We have to do with molar, not molecular nor atomic activities. Nature's jack plane and the plow are the things we have to consider, not the microscope nor the vernier. We want to examine, not the small forces that simply helped out, but the great forces that have made the mighty changes on the earth. The rocks decay, we don't care why. The mountains and plateaus rise, we don't know why. All we want to know is what effect these changes have upon man's dependence upon the earth and conquest of it. That man is not dependent upon the earth for his condition and subsistence none of us would for a moment claim. Artificial as our lives may have become, yet in their finality they hark back for everything to mother earth, and it is her moods that sooner or later determine what we are to do and be. Our conquest of the earth, like our conquest of everything else, will depend upon how well we understand the situation we are called upon to meet. It is hardly profitable for us to waste our time digging artesian wells on the rocky slopes of old granite mountains or to dig for gold in the stratified beds of the Mississippi valley. We would hardly expect to find a large city at Crawford Notch or to learn of a manufacturing town at the mouth of Penobscot. "Tear our hair" all we have a mind to, we generally do just about as old mother earth has arranged for us to do. As it is interesting as well as profitable for a man to know what he is allowed to do and how he is allowed to do it, so is it interesting and profitable for us to know something about the earth and its "thou shalts."

Let us, then, remember that in teaching physical geography not man alone nor the earth alone are the important factors, but

that it is man and earth with which we have to deal. A teacher cannot get this humanistic aspect too clearly into his mind. Boys and girls are not interested in abstractions. They may do for the doctrinairs, but for the full blooded boy who intends to get out into the world and make money and reputation by dealing with men and materials they are about as attractive and nourishing as saw-dust pancakes. He wants to know what effect the thing you are trying to teach him has upon the present or the past races of men. If physical geography will explain history or present human conditions to him, he will study it, be interested in it and try to really think about it. If not, he will read it, try to recite it, and readily forget it. This does not mean that all the abstractions and difficulties must be taken out of the science. It means simply this: See that all the teaching is tied up to something that a pupil really believes has somewhat to do with the things in which he is interested. If the boy lives on a rocky New England farm, cause him to realize clearly why his father does not raise great fields of wheat or ride a sulky plow or use a four-horse reaper and binder in getting in his grain. If he lives in a manufacturing town, let him try to decide why there is manufacturing in the town and why they manufacture what they do. I will admit it is rather hard in the present days af advanced psychology and pedagogy to tell exactly what we poor school teachers are placed on this earth for. However, until the contrary is more conclusively proved than at present, let us take it for granted that one of our functions at least should be to knock a little thinking, either into or out of a boy's head. To be sure, the subject of physical geography has to deal mostly with generalities and things in the large, but boys and girls rather like this. They have not yet come to the point where they want the government to coin five-mill pieces so that they can split a cent. Life and the world is big to them. This isn't a bad thing, either. We all of us become withered up soon enough, become pessimistic and look at the small side of life. Will not the study of the grand products formed by the mighty tools of the Almighty hand stimulate the mind to noble thoughts and aspirations more strongly even than the study of man's greatest deeds and thoughts? And after all, what is education but an attempt at inspiration? If its aim is simply material-

istic, then the boy should be taught to read, to write, to figure, and then be placed in the shop. We none of us believe this, however. We want to fill the mind with the best, the most noble and elevating incentives, that he may live for something besides the attaining of mere subsistence and of self-gratification. Let us, then, try to show him something of the grandness of Nature, and through Nature of Nature's God. If physical geography can aid in this attempt, by all means let it be taught him and taught him aright.

If we grant, then, that physical geography is a worthy subject for our study, how ought it to be taught? A subject may be ever so worthy and ever so valuable, and yet so taught that it will be dull and almost valueless. Now, almost everybody thinks that he knows enough to teach physical geography. I am told that the embryo teachers in sending in a statement of their qualifications to the agencies almost invariably assert that they are able to teach this subject. Many of them, of course, never studied it a day or ever did more than to look through the pages of some antiquated textbook, and perhaps try to fasten in their minds a few statements which, as Humboldt used to say, "are very interesting, if true." Whether they are true or not, these teachers have not the slightest conception, for all their knowledge rests upon the authority of the particular book they happen to have in hand. The work of such teachers we cannot expect to be instructive, inspiring or reliable. A teacher never taught anything successfully that he had not spent some time and energy preparing himself to teach. He would not think of attempting to teach mathematics or Latin or Greek unless he had studied them and studied them for a considerable time. And yet these subjects are narrow in their elementary scope, and a person may be a pretty successful drill master in the elements without having very much knowledge of the subject. Physical geography, however, even in its elementary aspects, must be broad. It must embrace much general knowledge and the power to draw correct inferences from observed and recorded observations. This ability cannot be obtained from simply reading a textbook. It must come from proper instruction and proper thinking. The mind that is to broaden the pupil's mind must itself be broad. Interest and

inspiration can come only from one who has a grasp of the subject and can add to the mere statements of the textbook some personal experience or acquirement. These statements are applicable to all subjects, but they peculiarly apply to this subject, where the eye and the observing power must be called into play as well as the printed page and the memory.

Now the fact of the case is, physical geography is one of the hardest subjects in our high school course to teach, because it is not simply a book or laboratory subject. It must combine the book, the laboratory and the field. It must call in play the retentive, the productive and the observative faculties. Some subjects can be learned from books, some from books and laboratory, some from books and field, but physical geography needs book, laboratory and field. Embracing all three of these methods, it has a certain value of which no other subject can boast. The fact that it corrolates these three methods and brings each of them to bear upon its continuous development peculiarly intensifies its value. The trouble is that the physical geography is rarely worked for what it is worth in the educational system, because of the newness of development along this line. We have not yet assimilated the subject into our curricula. In many schools it is rather a fill-in than a filling subject. It occupies a place where there can't anything else be easily put. It is taught by the teacher who really can't very well do anything else, and is taken by the pupils who really are not exactly suited for anything, and is taught with, well, any book that is easy. Under these conditions, no wonder that it is considered dull and uninteresting.

Let us, then, concede that the *sine qua non* in the teaching of physical geography is a knowledge of the subject on the part of the teacher, that this subject like others must be one which has been thoroughly studied. Let the teacher of physical geography feel that this subject deserves his careful preparation and energy while instructing as well as any other. Where there is a will there is a way. When it is really for the advantage of us teachers to know a subject, we go to work and find out where and how to learn it. A few years ago any one was supposed to be able to teach physics, but the grade of work demanded has risen in the last few years, and now every one that teaches physics makes

some special preparation for the work. When a man is engaged to teach the subject, inquiries are made as to whether he is qualified. Men find it necessary to their procuring positions that they give time and work to this subject and they do so. When it becomes apparent that the teacher of physical geography must needs be prepared for the work before taking it up, then this preparation will be made. There is no reason why this should not be as well taught as any other subject. It can be studied as readily and acquired as easily. Several places in this country where the subject is well taught may now be found. Then, too, there are the summer schools, where good courses are given every year. These will give a good start in the preparation, and here, as elsewhere, a right start is one of the most important things. It must be followed, however, by continual reading, study and, if possible, travel, to keep in touch with the developments. Physical geography is not remaining stationary; new things are being found out and new methods of investigation are constantly being devised. The field is open; there is no best method; every energetic teacher is trying to see if he cannot discover some way that is especially adapted to his needs. When the broad view of the field is once gained there cannot be too much of this independent effort. The best way to teach the subject will be discovered by a lot of patient workers working together and honestly trying to find out how to accomplish the best results. And then, too, there can never be any absolutely best method, thank goodness. The teacher in New Hampshire ought not to teach the same as one on the Alabama coastal plain. The school work in physical geography must have a local flavor. It needs to proceed from the seen to the unseen. The local surroundings must furnish the base level for reckoning. You cannot build an air castle of geographical forms; there must be a foundation for the structure laid at home. Here lies a source of great advantage, but also of great difficulty. However, when teachers can get the proper training the difficulties will be done away with, but the advantages will remain.

There are few places which do not show in miniature many of the great features of the earth's surface. The plain, the hill, the valley and the brook are typical of the great plains, the moun-

tains, the great valleys and the great rivers. Their influence upon population, too, is in a small way the same as that of these larger features. The plains in New England are generally sandy and are not such good farming lands as those of the great plains of certain parts of the earth, but, like them, the land is easily cultivated, the roads run in straight lines from one point to another, the valleys cut deeply into the soft soil, the wells must be dug deep and manufacturing is not found.

(*To be continued.*)

SOME WAYS OF DEPRIVING GERMINATING SEEDS OF AIR.

BY LOUIS MURBACH.
Instructor in Biology, Central High School, Detroit, Mich.

In schools where an air-pump is not always at hand for removing air from soaked seeds, to lead pupils to see the need of oxygen in germination, the vacuum of the physicist's water-hammer may be made to serve the same purpose. With a little practice, some glass tubing and an alcohol lamp (Bunsen burner is better), ten minutes will suffice to put the seeds in the vacuum.

Close, by softening in the flame, the end of a glass tube ten inches long by one-fourth inch in diameter, and drop small soaked seeds down into the closed end. Push down a little coil of wire or bristles to hold the seeds in this end when the tube is inverted. After filling the tube one-third full of boiled water, draw out the open end. Heat the tube in the flame until it is soft enough to bend easily, and break the drawn-out part where it is one-sixteenth or one-thirty-second of an inch in diameter. Now hold the tube carefully in the flame just below the water level until the water boils gently. The steam formed drives the air out of the tube, while the seeds are too far below the flame to be injured. As quickly as possible seal the fine tip by holding in the hottest part of the flame and allow the tube to cool before turning it over. The vacuum may be known by the "hammering" of the water when the tube is shaken endwise. If successful, the seeds will be in a

moist vacuum when the tube is turned over. If not successful, the point of the tube may be broken off and the process repeated..

After three or four days, other seeds of the same lot having germinated in the air, the seeds in the tube may be removed by breaking it, and if kept in a moist chamber, will germinate.

Where mercury and a glass tube of barometer length (about thirty-three inches) can be had, a more satisfactory vacuum may be made. Into the closed end, as in the first case, drop or push some small soaked seeds (morning glory, alfalfa) and then a little coil of wire to keep them in this end. Fill the tube with mercury, tapping and turning the tube from time to time to remove air. Invert the tube in a dish of mercury and leave until some seeds of the same lot, kept in a moist chamber near by, have germinated. After pupils have written up the experiment, remove the seeds from the vacuum and they will germinate rapidly, showing that they were not killed.

A very simple method that can be used with young students, but less certain unless very carefully done, is to displace the air with carbon dioxide from the lungs. After soaked seeds have been placed in the bottom of a Mason fruit jar (pint) the air is replaced by breathing through a glass tube for several minutes, then cautiously withdrawing the tube until the cover can be slipped on in the same careful way, and the jar sealed air tight.

In all these experiments the seeds should not be soaked too long.

A NEGLECTED FEATURE IN FERN STUDY.

BY J. A. FOBERG.
English High School, Chicago.

The careless visitor to the ferneries of our parks does not see the tiny, green, heart-shaped growths on the rocks and soil near the ferns, and is probably surprised when they are pointed out to him and spoken of as fern-plants. These "fern-prothallia" of the botanist are developed from microscopic, non-sexual spores borne

upon the under surfaces of fern-fronds; and upon them are developed the sexual organs and spores from which grow the ferns of ordinary speech. To study these prothallia, they must be specially prepared, and the microscope must be used.

The plants can be collected in any fern-house, preferably from the rocks, since then fewer particles of soil are entangled among the root structures. A pair of curved forceps, or an ordinary knife-blade, may be employed to remove them from the rock, care being taken to prevent bruising. The prothallia may be at once dropped into 2 per cent formalin, which is a killing and preserving fluid, and may be left in this until wanted. A fairly satisfactory method of then preparing the prothallia for study is this: Remove the prothallia from the formalin, and wash thoroughly in clear water; place for three or four hours in a mixture of 3 parts water, 1 part glycerine, and then for the same length of time in a mixture of half water, half glycerine. Put now into a liquid 1 part water, 3 parts glycerine, and let stand until the water evaporates, leaving the prothallia in concentrated glycerine.

Permanent mounts may now be made by making a ring of balsam in the middle of each slide, placing in the center of each ring a drop of glycerine with a prothallium, lower side up, and covering with a cover-glass supported by three or four fragments of thin glass. One or two experiments will be necessary to determine the right amount of balsam and glycerine to use, so as to avoid air-bubbles.

For the benefit of those unfamiliar with this small but interesting stage in the life history of the fern, a few words of description may be added. The prothallus varies somewhat in size, according to the species of fern producing it, but it is never large and always requires the aid of a compound microscope to make out its structure. It may commonly be seen by the unaided eye as a very small heart-shaped thallus. On examination with the microscope, viewing the under surface, the structure is largely cellular, with numbers of hair-like rhizoids extending from the central, thickened basal portion. Mixed up with the rhizoids will be found the remains of sporangia, and here and there very small rounded cells, usually with a darker central marking, the *antheridia*.

Near the sinus or notch of the prothallus a number of small, oval or rounded dark structures may be seen, often appearing to be made up of minute cells. These are the *archegonia*. By the fusion of the contents of antheridium and archegonium, a sexual spore or "egg" results, which on germination produces the fern plant, as it is commonly known.

A CONVENIENT METHOD OF DETERMINING THE DENSITY OF AIR.

BY A. W. AUGUR.
Instructor in Physics, Lake View High School, Chicago.

A rapid and reasonably exact method of determining the density of air both for the laboratory and lecture room is of considerable interest and importance to every teacher of elementary science. The method here described is believed to meet the requirements of simplicity, speed, and accuracy better than most of those commonly employed.

The apparatus required consists of a copper or brass globe provided with a stopcock, such as usually forms one of the accessories of an air pump; a balance weighing to centigrams; a bicycle pump; a two-gallon bottle provided with a four-hole rubber stopper, and graduates or graduated flasks for measuring the volume of water. The globe is weighed filled with air at atmospheric pressure, the stopcock being left open. With the bicycle pump as much air is forced into the globe as is thought safe. If the globe has soldered joints, 1.5 to 2 grams of air for each liter of capacity will usually be safe; but if spun without joints, a much larger amount of air could be forced in. The globe is again weighed and the weight of the air introduced noted.

The large bottle is filled about two-thirds full of water at the temperature of the room, and a layer of heavy lubricating oil poured on top to check the formation of water vapor when the relatively dry air from the globe is admitted. Kerosene might be

used instead of the water and heavy oil with good results, but was not employed by the author. A bent glass tube passing through the stopper nearly to the bottom of the bottle and provided on the outside with a rubber tube and pinch cock acts as a siphon for drawing off the water. A second glass tube with a rubber connection for attaching to the stopcock of the globe passes through the stopper and provides for the admission of the air.

A U-shaped open manometer tube 25 centimeters high, and containing about ten centimeters of water with the outer end provided with a rubber tube and pinch cock, passes through the third hole in the stopper. A thermometer is inserted in the fourth hole, the stopper is wired in, and all the connections made tight with soft wax or paraffine.

The globe is attached to the inlet tube and enough water allowed to run from the siphon to make the pressure, as indicated by the manometer, the same inside the bottle as outside. The open end of the manometer is then closed by means of the pinch cock and the air from the globe admitted rather slowly, taking perhaps two minutes to complete the operation. In the determinations made by the author the water is drawn from the bottle directly into liter flasks, the fraction of a liter being measured in a 500 cc. graduate. When apparently enough water has been drawn out the pinch cock is removed from the open end of the manometer and water allowed to run in or out as may be needed to make the pressure inside and out the same. As the air in the globe is cooled by its expansion, two or three minutes must be allowed for it to again reach the temperature of the room. The thermometer and barometer readings are then noted.

The following are fair samples of the results obtained after reduction to 0 degrees and 760 mm.:

Density.	Per Cent Error.
0.001297	+0.31
0.001279	—1.08
0.001289	—0.31
0.001293	0.00
0.001291	—0.15
0.001302	+0.70

The largest error in 15 successive determinations was 1.3 per cent, the average error being 0.54 per cent. The weight of the air taken was from 3 to 4 grams, and the weighings were accurate to centigrams only. The time required for a determination never exceeded 20 minutes, and was usually about 15.

Aside from instrumental errors, the chief sources of error in this method are due to the cooling of the air on expansion, and the formation of water vapor when the relatively dry air from the globe has displaced the water in the bottle. If the bottle is not more than two-thirds full of water and the air is admitted slowly, the error from cooling, which tends to make the result too large, will be small. If we wait till the air has fully returned to the temperature of the room so much water vapor is likely to form that the result is certain to be too small. Until the layer of oil was used this was uniformly the case. The most satisfactory results were obtained when from two to three minutes were taken for the admission of the air and the drawing off of the water.

EXPERIMENTS ON THE REMOVAL OF OXYGEN FROM THE AIR.*

BY O. OHMANN.
Berlin.

Quite a number of methods have been devised to separate the oxygen from a measured volume of air, and thus to show the ratio of the volumes of oxygen and nitrogen. Phosphorus and pyrogallic acid in alkaline solution gives perhaps the most accurate results; copper is good, but requires rather complicated apparatus, while, of course, the use of combustibles, such as alcohol or a candle, is barred, because carbon dioxide is formed, which cannot be readily separated from the nitrogen.

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*Translated for "School Science" from *Zeitschr. f. phys. und chem. Unterricht* XIII. 333.

In what follows will be shown how the oxygen may be removed by burning hydrogen, and that a very satisfactory determination of the ratio of the volumes of oxygen and nitrogen can by this means be made. The experiment is not offered as a substitute for other methods of making this determination, but it is thought that it may well be incorporated in the study of water or the general phenomena of combustion.

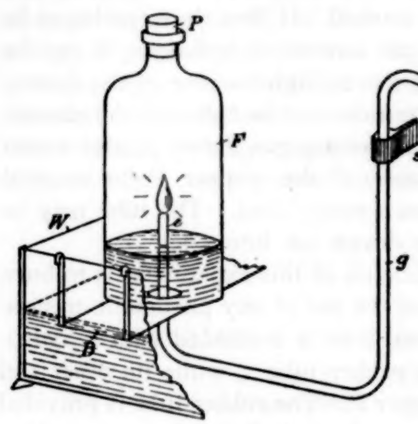


Fig. 1.

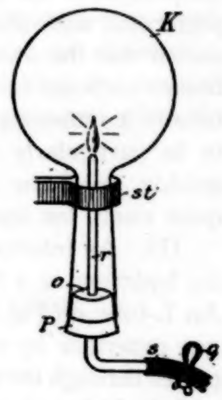


Fig. 2.

I. A glass tube bent as shown in Fig. 1 is joined at *k* with a Kipp hydrogen generator. The part of the tube marked *e* (the end of the tube should not be drawn out of the jet) is pushed up through a hole in the bridge of a pneumatic trough. Hydrogen is passed through the tube and lighted, the flame at first being made as small as possible. A bottle F (about 12 cms. in diameter and 36 cms. high), with its bottom cut off, and closed with a rubber stopper P, is set down on the bridge over the flame which is at once made somewhat larger. The position of the tube *g* held at the clamp *st* of a stand is so regulated that it reaches only about 2 cms. above the water which may rise in the bottle. The flame burns as usual for a short time, then becomes pale-blue, and finally colorless. It is, nevertheless, possible to tell just when the flame goes out, and the instant this takes place, the current of hydrogen must be stopped. The water, which has already risen

somewhat, now rises rapidly and in a little while reaches the same height it would in an experiment with phosphorus. The removal of the oxygen by means of burning hydrogen has the advantage over phosphorus not only in its great simplicity, but also in there being no dense fumes formed which must be allowed to settle before the residual gas can be shown to be nitrogen.

II. Later, when illuminating gas or the phenomena of combustion are being studied, this experiment may be repeated, and the position of the water level marked. If then the experiment be performed with illuminating gas instead of hydrogen, it can be shown that the water does not rise as high because of the formation of carbonic acid gas. Attention may be called to the characteristic lengthening of the illuminating gas flame; it also seems to be particularly sensitive, since if the stopper P be inserted quickly, the flame is sometimes extinguished. The tube may be quite small, but should not be drawn out into a jet.

III. An interesting modification of this experiment is to burn the hydrogen in a flask without the aid of any pneumatic trough. An L-tube *r* (Fig. 2) of 4 mm. bore is connected with a hydrogen generator by means of a rubber tube *s*, while its other end passes through the rubber stopper P. The rubber tube is provided with a pinch cock *q*. The stopper fits in a flask of about one liter capacity, of not too thin glass and supported by means of a clamp *st* on a stand. The rubber stopper and *r* are lowered out of the flask, hydrogen passed and lighted. The flame is made very small at first, and the narrower end of the stopper wet with water from a wash bottle, so as to insure an air tight joint when the stopper is inserted in the neck of the flask. The flame behaves just as in the preceding experiment, and as soon as it goes out, the pinch cock *q* is closed. The end of the tube *s* is placed in a vessel full of water, and when the apparatus is at the temperature of the room, the pinch cock is slowly opened. The water gushes in and soon fills the flask one-fifth full. The experiment is totally devoid of danger in spite of the heat of the flame.

IV. The last experiment may also be performed with pure oxygen. The air is displaced by a current of oxygen, the flask is closed with a rubber stopper, inverted and fixed in a clamp just as above. The jet of hydrogen is ignited, the solid stopper re-

moved and the flame pushed up into the flask as rapidly as possible. The flame continues to burn for about eight minutes. At first it becomes smaller and even passes down a few centimeters into the tube. Shortly before it goes out, it lengthens again, and it is advisable to shut off the current of gas a little. The flask is allowed to cool slowly, and then the pinch cock is opened very gradually. A little gas is always left in the flask, the nature of which may be established as follows: The tube *r* is drawn almost through the stopper P, the flask is set upright, and a solid stopper quickly substituted for P. The flask is supported on a stand, a blazing splinter of wood brought to its mouth, and the stopper removed. The explosion which ensues shows that the most of the residual gas is hydrogen, which must have entered when the flame was just on the point of going out.

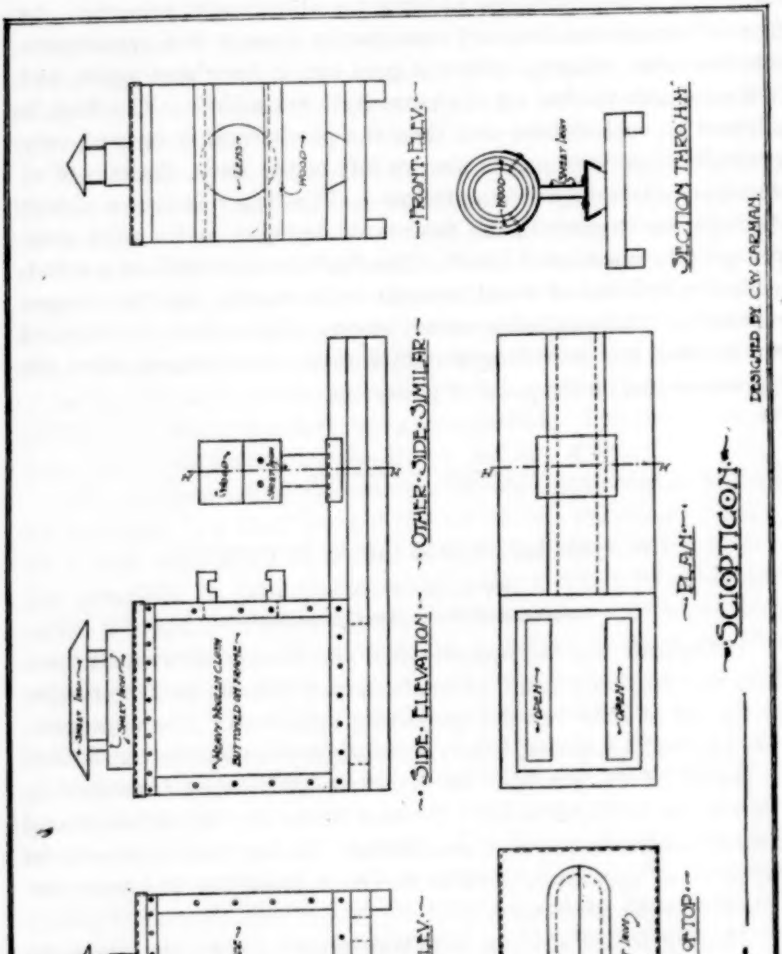
A SIMPLE FORM OF SCIOPTICON.

BY C. W. CARMAN.
Department of Physics, The Chicago Institute.

It happens not infrequently that the teacher in a small town finds that his work could be made more profitable and interesting by the aid of some form of projecting apparatus. The appropriation for such purposes, however, is often found to be too limited to permit of the purchase of the cheapest lanterns furnished by the regular manufacturers. Several times the writer has found himself confronted by such conditions. Rather than to do without the piece of apparatus, even in its crude form, one has been constructed in the laboratory.

Hoping to aid any one who may wish to know the necessary expense and a method of construction, working drawings, specifications and an estimate are here submitted. If the instructor should not have laboratory facilities sufficient to do the work himself, the carpenter and tin-shop will furnish the same at very small expense.

Though it is not to be presumed that the best results can be obtained from the apparatus described below, it is believed that



FRONT ELEV.
LENS
WOOD
SECTION THRO' H.H.
WOOD
SHEET IRON
SIDE ELEVATION
OTHER SIDE SIMILAR
SHEET IRON
HEAVY MUSLIN CLOTH BUTTONED ON FRAME
PLAN
OPEN
OPEN
REAR ELEV.
SAME AS SIDE
PLAN OF TOP
SHEET IRON
SCIOPTICON
DESIGNED BY C.W. CARMAN.
1 FOOT

one who secures all results that are possible from it will find himself well on the way to the possession of better apparatus.

Specifications.—The apparatus consists of a pine board 24 inches long and 8 inches wide, resting upon two strips 1 inch square and 24 inches long. On one end of the board a rectangular frame, 10 inches long, 8 inches wide and 11 inches high, is built out of pine strips 1 inch square. Extending from this frame along the center of the board to the other end is attached a guide for the objective support. The front of the frame is closed by a board one inch thick, in the center of which is a 4½-inch opening for receiving the condensing lens. Grooved strips are secured on the front to serve as a slide-holder. The sides and rear are closed by means of woolen cloth buttoned on the frame. The objective support is constructed of sheet-iron and a hollow wood cylinder. The top is constructed from sheet-iron in a manner clearly shown in the drawings.

Three boards 2 feet long and 1 foot wide, fastened together at the ends by means of hinges, in such form as to make an adjustable letter "Z," is a convenient and cheap support by means which the height of the sciopticon can be regulated.

The following is an estimate of the expense required:

Lumber, screws and carriage buttons	$0.30
Sheet-iron top and objective support	1.50
Condensing lenses, mounted	2.00
Objective lens, mounted	3.00
Oil lamp with reflector	0.50
Cloth for sides and screen	0.60
Total	$7.90

The apparatus may be converted into an heliopticon for the additional sum of $5.00.

Other forms of illuminants may be obtained at the following prices: Acetylene outfit, $16.00; lime light burner, $6.00; incandescent electric lamp, $2.50; incandescent gas burner, $1.00; arc lamp, $8.00.

The most desirable form of illuminant depends upon the locality in which the apparatus is to be operated. Electricity is the cheapest and most satisfactory, if it can be obtained.

Notes.

ZOOLOGY.

In studying infusoria it is customary to feed them powdered carmine, that the food vacuole formation and movement may be seen. Frequently the results with ordinary powdered carmine are unsatisfactory on account of the little which is taken. Much more striking results are obtained with using *water color carmine*, such as is employed by artists, and is to be had in little porcelain cups. A very small quantity is rubbed in a drop of water on a slide and the infusoria added.

Detroit Central High School. L. MURBACH.

Slowing of the Movements of Infusoria. In our work the method of using cotton to keep infusoria in the field of the microscope has been far from satisfactory. A solution of gum arabic has been found to answer very well. By using the proper strength of solution the movements of the infusoria may be slowed to any desired degree. While the cilia continue to vibrate, the rate of vibration is much lessened, so that they may be seen without much difficulty.

Lee, in the "Microtomists' Vade Mecum," states on the authority of Eismond that peach gum may be used for this purpose, but that gum arabic will not do. I do not understand how such a conclusion has been reached. We have employed gum arabic successfully for this purpose for several years. The chief advantage of gum arabic lie in the fact that it is easily soluble in cold water, while peach, cherry or plum gum must be boiled in water and be diluted to the proper consistency.

Lake View High School, Chicago. E. A. BEDFORD.

Study of Earthworms. Glass tubing of a diameter slightly larger than that of the earthworm is fashioned in a flame into tubes closed at one end and about 20 cms. (8 in.) long. In these are placed entire earthworms previously killed in the usual manner. The remaining space is filled with a 3 per cent solution of formalin. The tube is closed by inserting a cork, which is cut off even with the edge of the glass. Then the whole end is covered with sealing wax.

Earthworms from which the dorsal body had been removed to show the alimentary canal and the dorsal blood vessel were also placed in tubes. Also earthworms from which the alimentary canal had bee nremoved to show the nerve cord.

These tubes were found to be of great value used in connection with the other material for the study of the worm.

Lake View High School, Chicago. E. A. BEDFORD.

To Study the Mouth Parts of the Crayfish, the appendages of one side are sewed in their proper order to a strip of stiff linen paper, which must not contain any glue. This is placed in a screw-topped vial about 13 cms. (5 in.) high and 2 cms. (¾ in.) in diameter, and the vial filled with a 3 per cent solution of formalin. Some of the advantages of this method are that the appendages are always in good condition; they are not injured by handling; they are always in their proper order and they may be kept indefinitely.

In my classes these preparations are used chiefly in connection with the study of the living crayfish. The pupil first studies the appendages in a vial. He then determines their positions on the crayfish and observes their use when the crayfish has been placed in a jar of water, especially while the crayfish is eating. After the pupil has finished the study of the other appendages and is prepared to trace the homology of the different appendages he has the mouth parts in good condition for study.

The results obtained in my classes have been much more satisfactory than those obtained by having the pupil remove the mouth parts of a dead crayfish.

Lake View High School, Chicago. E. A. BEDFORD.

BIOLOGY.

Effect of Extreme Cold on Vitality. As by the aid of liquid air and hydrogen very low temperatures can be produced and maintained for some time, several investigators have subjected seeds, ferments, bacteria, etc., to the action of these low temperatures with a view to ascertaining the effect on their vitality. Thus Pozerski (Comptes rendus de la Société de Biologie, LII., p. 714, 1900) placed a number of soluble ferments in three separate sets of test tubes; put one set in liquid air at a temperature of —191° C.

for forty-five minutes, kept a second set at ordinary temperatures and boiled the third set. Equal amounts of the ferments from each set were then mixed with the same amount of the substance to be fermented, and all allowed to stand at 40° C. for the same length of time. It was found that the cooling had had no perceptible action on the ferments.

Allan MacFadyen (Proceedings of the Royal Society of London, LXVI., p. 180, 1900) describes the following experiment: "Fifty liters of the laboratory air about six feet from the ground were liquified at atmospheric pressure in a glass bulb by means of boiling liquid air *in vacuo*. The temperature reached was about —210° C. The bulb was then sealed off, the contents being still at a temperature below zero, and was subsequently opened and washed out with sterile broth. A series of plate cultures were made from the broth in nutrient gelatine, agar-agar and sugar agar, and were incubated under aërobic and anaërobic conditions at 22° and 37° C. for a period of ten days. The anaërobic plate cultures remained sterile. The aërobic plates yielded forty-four organisms, which had survived an exposure to —210° C. The organisms were representative types of those met with in the air, viz., molds, bacilli, cocci, tortulae and sarcinae."

Sir William Thistleton-Dyer (Proceedings of the Royal Society of London, LXV., p. 361, 1900) had a half dozen representative lots of seeds "soaked in liquid hydrogen" for six hours, and yet they "did not show the smallest visible trace of the ordeal to which they had been subjected. They were sorted out and immediately sown," and all without exception germinated.

GEOLOGY.

A group of papers in the Transactions of the American Institute of Mining Engineers, Vol. XXX, 1900, upon the nature of the deposition and the classification of ores presents many points of general interest.

These are: The Origin and Classification of Ores, by Chas. R. Keyes; Some Principles Controlling the Deposition of Ores, by C. R. Van Hise; Secondary Enrichment of Ore Deposits, by S. F. Emmons; Enrichment of Gold and Silver Veins, by Walter H. Weed.

The first of these is an attempt to classify the ores upon the geological control of their deposition and form. As will be seen by the following table which sums up the classification, the scheme regards as more important the geological occurrence of the ores than the nature of their formation:

CLASSIFICATION OF ORE DEPOSITS.

Groups.	Categories.	Miners' Forms.
I. HYPOTAXIC. Mainly surface deposits.	Aqueous transportation.	Placers.
	Residual cumulation.	Pockets (in part).
	Precipitative action.	Bog-bodies, some beds, layers.
II. EUTAXIC. Chiefly stratified formations.	Original sedimentation.	Beds, strata, layers.
	Selective dissemination.	Impregnations (in part).
	Emponded amassment.	Masses (in part), some segregations.
	Fold-filling.	Saddle-reefs.
	Crevice accretion.	Gash-veins, stock-work (in part).
	Concretionary accumulation.	Nodules.
	Metamorphic replacement.	Fahlbands (in part), beds.
III. ATAXIC. Predominantly unstratified and irregular bodies.	Magmatic secretion.	Masses (in part), some lenses.
	Metamorphic segregation.	Stocks, lenses.
	Fumerole impregnation.	Contact-veins, some impregnations.
	Preferential collection.	Chambers (in part), some pockets, linked-veins.
	Fissure occupation.	Attrition-veins (in part), some linked-veins, true veins.

The second paper, by Professor Van Hise, has been published in a somewhat less extended form as an address before the Western Society of Engineers, at Chicago, in the journal of that society for December, 1900, and in the Journal of Geology for November-December, 1900.

The paper deals with the movements of underground waters and their action on the ores. The deposits are the result of two concentrations; the first by ascending waters and a second by descending waters actuated by gravity and acting through the zone of weathered and fractured rocks. Deposits are arranged in three classes: Ores of igneous origin; ores which are the direct result of processes of sedimentation, and ores which are deposited by underground waters.

The last class is the only one considered by the paper, and is divided as follows:

"(a) Ores which at the point of precipitation are deposited by ascending waters alone. These ores are usually metallic or some form of sulphuret; but they may be tellurides, silicates, or carbonates.

"(b) Ores which at the place of precipitation are deposited by descending waters alone. These ores are generally oxides, carbonates, chlorides, etc., but silicates and metals are exceptionally included.

"(c) Ores which receive a first concentration by ascending waters and a reconcentration by descending waters. The concentrating by ascending waters may wholly precede the concentration by descending waters, but often the two processes are at least partly contemporaneous."

The last class is regarded as by far the most common.

Professor Emmon's paper covers somewhat the same ground as regards the action of ground waters and the local concentration of ores by descending water. His remarks upon the relation of the physiographic and climatic changes are of especial interest. He says:

"Active degradation favors the accumulation of enrichment, while prolonged degradation of a region, resulting from physiographic revolutions, may result in successive migrations of material and the accumulation in a relatively shallow zone of the metals derived from many hundreds, and possibly thousands, of feet of the vein worn away in the degradation of the land. Climatic conditions, rainfall or aridity, warmth and rapid alteration of vein fractures, are agents affecting surface weathering, and hence, also, enrichment.

"Active degradation of a region, that is, rapid weathering, favors enrichment by the quickness with which it removes the upper already leached part of the vein, so that a larger amount of the vein-matter is lixiviated in a given time than would result from the slower wasting of the land. Such enrichments are favored by high latitudes. Moreover, the mountainous regions are those in which secondary fractures are most apt to be found.

"Prolonged degradation is favorable for a similar reason, since time is a factor in enrichment and changes in elevation, etc., affect the rate and the progress of decay of the vein; while the crustal movements accompanying the physiographic changes favor fracturing of the earlier deposit, increasing facility of leaching and place for deposition. If a region passes through several cycles of erosion and elevation, it is evident that their result is likely to be a succession of enrichments in which not only the original ore is leached, but the earlier enrichment deposits migrate downward. At Butte, Mont., the region has passed through several very pronounced changes in elevation since the formation of veins in Tertiary time.

In early Tertiary time the present topography of the region was blocked out, and mountain ranges and deep valleys carved. This was succeeded by earth movements by which the streams became clogged or the valleys dammed, forming lakes; while volcanoes broke out at numerous places and showered ashes and scoria over the region. The valleys were silted up or in part filled with volcanic débris before crustal movements drained the valleys and altered the divides. More recent movement, possibly still continuing, is marked by faults and a reversing of the stream courses. The old valley at Butte is filled by hundreds of feet of débris, and a mountain wall 2,500 feet high marks a north and south fault-line. These changes all caused a migration of water-level facilitating the processes of weathering and enrichment, and the great bodies of rich copper ores of the region are believed to be in part due to this cause."

In all the papers there is a complete agreement upon the fact that the deposits are largely superficial in nature and due to secondary processes of concentration.

State Normal School, Milwaukee, Wis. E. C. CASE.

CHEMISTRY.

Hydrogen and Hydrocarbons in the Atmosphere. A. Gautier has found that 100 liters of air collected on the streets of Paris contain 19.4 cc. of hydrogen, 12 cc. of methane, 1.7 cc. of benzene and its homologues, and 0.2 cc. of carbon monoxide and other hydrocarbons. Air collected over the sea and in forests always contains hydrogen, although in somewhat smaller amounts. According to the kinetic theory of gases, the molecules of hydrogen are so light and have such rapid vibratory motions that they escape from the atmosphere into interstellar space. As a matter of fact, large quantities of hydrogen are introduced into the atmosphere by volcanoes and through decay of vegetable and animal substances. Volcanic rocks, and especially granite, give off hydrogen in abundance when heated with acids or even water. If, then, the hydrogen did not pass out of the atmosphere almost as soon as produced, the relative amount of it would be much greater.

Hydrogen for Illuminating Purposes. Hydrogen prepared by electrolysis is threatening to supplant acetlyene. Dr. Schmidt of Switzerland finds that the light given out by hydrogen burning in a mantle (as in a Welsbach burner) costs per candle power less than one-half what acetylene does. Furthermore, hydrogen yields no carbonic acid gas, is not poisonous and uses less oxygen than any other illuminating gas. It is also claimed that the danger of

explosion is much less than with acetylene. The electrolysis is carried out in iron vessels with iron electrodes, the electrolyte being a solution of a caustic alkali.

Preparation of Ozone. When oxygen is formed in a chemical reaction taking place at low temperatures it shows a tendency to polymerize and produce ozone. Such is the case in the reaction of sulphuric acid on barium dioxide or potassium permanganate. But even at temperatures not higher than the ordinary, ozone is more or less completely changed into oxygen. In 1891 Prof. H. Moissan showed that water is decomposed by fluorine with formation of hydrogen fluoride and ozone, and when single drops of water were made to fall into an atmosphere of fluorine the formation of ozone was so abundant as to be easily recognizable by its blue color. Recently Professor Moissan (Comptes Rendus, CXXIX., p. 570, 1899) has studied this matter more thoroughly, and has found that when a rapid current of fluorine is passed into water kept constantly at 0° C., a gas is obtained containing 14.39 per cent by volume of ozone. When not more than three liters per hour were passed into the water the ozone was only 10 to 12 per cent of the volume of the oxygen; and when the temperature rose above 0° C. the proportion of ozone was considerably less. It seems that it is perhaps possible to make use of this reaction to prepare ozone on a large scale for industrial purposes.

The Boiling Points of Zinc and of Cadmium are often chosen as fixed points in the measurement of high temperatures, and D. Berthelot therefore undertook to determine them as accurately as possible. (Comptes Rendus, CXXXI., p. 380, 1900.) Specially constructed electric furnaces were employed in which the heating was done by means of a current passing through nickel wires. The metals were prepared very carefully, so as to assure the highest degree of purity. The boiling of zinc was found to be 920° C., agreeing well with Holborn and Day's value (920° C.), as well as Callendar's (916° C.); Cadmium boiled at 778° C. differing somewhat from the older values; Becquerel (746° C.), Carnelly (763° C. to 772° C.), and Deville and Troost (815° C.).

Radioactive Elements. The property that uranium and thorium compounds have of sending out in the dark, without previous exposure to light, rays which act upon photographic plates, cause air to conduct electricity and excite phosphorescence has in the last few years received a good deal of attention. A similar radioactivity has been observed in compounds of barium, bismuth and titanium prepared from pitchblende and substances of presumably elementary nature, as radium and polonium have been obtained. Quite recently radioactive lead and radioactive compounds belonging to the rare metals of the cerium and yttrium groups have been isolated, which, when completely separated from uranium, thorium, barium and bismuth, still preserve their radioactivity. When the active lead salts are transformed into lead oxide their radioactivity is increased, just as is also the case with thorium and uranium.

Those who are interested in "radium" will find exhaustive accounts of this remarkable substance—perhaps element—in (1) *Popular Science Monthly,* July and September, 1900; (2) *Journal of the American Chemical Society,* September, 1900; (3) *Physical Review,* September, 1900.

A Statue of Lavoisier was unveiled in Paris on July 27, 1900. It stands in the Place de la Madeleine, facing the Rue Tronchet, near the house where Lavoisier lived for many years. The fund for the monument, amounting to 98,000 francs, was raised by international subscription. The dedicatory exercises were arranged by the French minister of public instruction, who accepted the monument for the city, the presentation address being made by M. Moissan. The bronze statue of the famous chemist, which was made by M. Barrias, stands upon a granite pedestal; the latter is ornamented by two bas-reliefs, one representing Lavoisier dictating an experiment to his wife in his laboratory, the other showing him in the act of expounding the result of some experiments to his colleagues at the French Academy. The dedicatory address was to have been made by M. Berthelot, but he was detained by illness. The monument is fittingly inscribed with a single sentence, which sums up Lavoisier's work: *"Fondateur de la chimie moderne."*

Lowell, Mass. LYMAN C. NEWELL.

Book Reviews.

Popular Astronomy, being the new descriptive Astronomy by JOEL DORMAN STEELE, Ph.D., revised and brought down to date by MABEL LOOMIS TODD. 13x19 cms., 349 pages. American Book Co., New York. 1900. $1.00. Judging from external appearances alone, we should scarcely recognize in this book under its new cover and new title a revision of Steele's *"Fourteen Weeks in Astronomy."* Upon turning the leaves, however, the old illustrations are seen to be generally retained, and a more careful examination shows that the plan of the old book has been quite strictly followed throughout. Nevertheless, the revision has been conscientious and thorough. The full extent of the changes necessary to bring the work strictly up to date, and to correct much that was unscientific in the old book, can be realized only by a careful comparison of the old with the new. In numerous instances paragraphs have been recast so as to render obscure and unscientific statements lucid and accurate, while minor verbal changes are almost innumerable.

Now and then one could wish that Mrs. Todd had been more radical in her work of revision, as, for instance, where she retains the useless distinction between the "sensible" (not visible) horizon, and the "rational" horizon. All of the important advances in the science during the past fifteen years receive due attention for a work of this scope. While most of the old illustrations have been retained, they have generally been made from new cuts. Several of the "less worthy" illustrations have given place to better ones, and a number of new illustrations have been added—notably a series of views of the solar corona, and a series of drawings of the surface of Mars.

As a result of Mrs. Todd's labors, we have an easy, popular work, at once teachable and scientific, well adapted to the needs of the smaller high schools which can devote but a limited amount of time to the study of the science.

Hartford, Conn. B. S. ANNIS.

A Brief Course in General Physics, Experimental and Applied. By GEORGE A. HOADLEY, A.M., C.E., Professor of Physics in Swarthmore College. 13x19 cms., 463 pages. American Book Co., New York. 1900. $1.00. This is a book of reasonable size, treating the subject to about the extent usual in books intended for secondary school use. The method of treatment is that of presenting the facts, illustrating by demonstrations and providing laboratory work and problems to emphasize the facts and concepts already obtained. By this method the laboratory work would appear to be placed in an inferior position.

The order of the topics is the usual one—Properties of Matter, Mechan-

ics of Solids, Liquids and Gases; Sound, Heat, Magnetism, Electricity and Light—and the proportion of space assigned to each is fairly divided. As a clear, well balanced presentation of the subject, the book is to be commended.

In matters of detail, the illustrations are mainly well chosen and executed, the general arrangement is good and the text is clear.

As is common with books combining text and laboratory instructions, the latter are too condensed in many cases to enable pupils to do the work without considerable aid, either oral or written, from the teacher, and some of the experiments, such as those calling for a buzz-saw or a lathe, would be rather difficult to carry out in an ordinary school. Much of the work would have to be done individually and could not be done by class-sections at the same time. The descriptions of several demonstrations are a little careless; for instance, in Experiment 6 (page 23), it would seem that the heat of the burning phosphorus would cause such an expansion that a part of the gas would escape.

It is to be regretted that more space could not have been devoted to the practical applications of the principles of physics, the treatment given to electricity being perhaps an exception.

To those desiring to teach physics according to the methods chosen, basing the work on presentation and illustration, the book is to be commended; to those preferring the more individual methods, in which the laboratory is made a basis for work, the book will probably not appeal.

The High School, New Bedford, Mass. CHARLES R. ALLEN

Experimental Chemistry. By LYMAN C. NEWELL, Ph.D.(Johns Hopkins), Instructor in Chemistry at the State Normal School, Lowell, Mass. 13x19 cms., xv and 410 pages. D. C. Heath & Co., Boston. 1900. $1.10. Of the numerous elementary chemistries published in recent years, not one has been presented to the teaching body in a neater style than this, and hardly one has departed farther from the established formula of presenting the subject. With a strong belief that a text-book is not a field from which to glean facts, the author presents a guide book to the student of chemistry, and in all cases where possible the student's work is put upon a foundation of experimentation.

The book would guide the student at first through a series of quantitative experiments with the elementary gases, requiring much skill in setting up and arranging complicated apparatus as well as in its manipulation. In many cases, also, apparatus is called for which on account of expense is not ordinarily found in the laboratories of even our best high schools.

The usual custom has been to regard experiments requiring accurate weighing and much apparatus as serving the best purpose of the student after he has gained some skill in handling chemical ware. While by the author's arrangement the student will be led to do careful work and to be more exact in his experiments, and thus be made to comprehend more clearly the object of his experiments, is it not true that in the case of the

average student more interest will be aroused by giving him some striking facts at the beginning and having him do some experiments where correct results are bound to result, notwithstanding the perverseness of nature and the lack of skill of the workman?

An excessive amount of time would seem to be required to complete the book, more, indeed, than can be given to the subject to chemistry in most high schools. If a pupil arranges his own apparatus, many of the experiments will take more than two hours, and if a school has three or, at best, four hours per week for laboratory work, certainly one hundred and thirty periods of laboratory work will prove insufficient. In addition, according to the methods of the best teachers, an equal amount of time will be required by the pupil to make drawings of his apparatus and for a clear exposition of his laboratory work in his note book. The description of the elements which is generally given in most text books is left to the pupil to be garnered from various sources. At the end of each chapter there are given class-room exercises, fifty-three in all, and each containing thirty to fifty questions, so the pupil will gain a great deal of experience in delving into the tomes of a chemical library containing some seventy-five suggested volumes; but all this takes time. The recitation on the laboratory work will require, say, an hour per week; at least two hours per week will be necessary to eliminate the chaff gathered with the wheat for the class work and one hour per week for a lecture, a complemental factor of some eight hours of school time. Stoichiometrical problems fairly bristle in every part of the book. Surely the additional time required to do these will bring the sum total to ten periods of recitation a week.

In addition to the time occupied in schools, there is hardly a doubt but that all a pupil's skill and ingenuity will be required not to make the study time devoted to chemistry out of school greater than in school. With several other studies, all of this time is quite out of the question.

In some ways, however, this is certainly an ideal book. It does not enter into the discussion of chemical compounds which are chemical curiosities, and it confines itself to the simple facts and theories of the usual courses in chemistry; but, as indicated above, in very few schools would there be the ability to complete the entire work, and it is so bound into a comprehensive totality that one cannot omit a single part of it without impairment of the whole. To any pupil who has developed a special adaptation for scientific work, this book will give an excellent training, and to normal students who have as their aim to prepare themselves in chemistry for a major study no book could better serve as a teacher's compendium and guide. If, too, a college student intends to try for honors in chemistry, this book will guide him through a valuable course, and it is just the book a college student needs to help clarify the usual lectures in descriptive chemistry. To teachers and embryo chemists this book should prove exceedingly helpful. The experiments are many of them new and simple, and hence valuable, and the progressive manner of presenting the subject suggests many new thoughts

to all. As a whole, the book tends to change our ideas and modify our methods and thus bring us nearer the needed Utopia.

North Division High School, Chicago. C. E. BOYNTON.

Laboratory Instructions in General Chemistry. Arranged by ERNEST A. CONGDON, Professor of Chemistry, Drexel Institute, Philadelphia. 14x21 cms., 110 pages. P. Blakiston's Sons & Co., Philadelphia. 1901. $1.00. Directions for the performance of 262 experiments of almost exclusively qualitative nature are given, to be used in connection with any standard text. In an appendix are directions for about a dozen quantitative experiments.

The directions are usually but bare outlines, and not an inconsiderable amount of preliminary demonstration and oral instruction is undoubtedly necessary on the part of the teacher to insure the student's performing the majority of the experiments successfully. Also quite an elaborate outfit of chemicals, apparatus and reference books is required.

The book is well printed and the numerous cuts are excellent; it is bound up with blank pages for notes.

For schools with well equipped laboratories and giving a rather more advanced course in General Chemistry than is customary in most high schools, this book will be found of much value.

C. E. L.

A School Chemistry. By JOHN WADDELL. 13x19 cms., xiii and 278 pages. The Macmillan Co., New York. 1900. $0.90. The evolution of the modern text book for laboratory studies in secondary schools has been very rapid in late years. The first books developing chemistry along this line were almost entirely qualitative and descriptive, the facts presented being in no essential particular especially calculated to furnish the basis of theory, while the idea of quantity appeared in the *discussion* of theory only. In fact, as Dr. Waddell says in his preface (referring to the impressions of beginners), "The theories do not seem to arise from the facts. If any connection is regarded as existing between the two, the theories are supposed to be the more fundamental," etc.

In the effort to correct this obvious fault, some of the recent books have undertaken to develop the entire subject in a purely quantitative way, practically ignoring the descriptive and qualitative phases. In most cases, these ultra-modern books are bound to have very little following, as the experiments as a whole, and many of the discussions are too advanced for the class of minds to be reached.

In the opinion of the writer, the successful books, and in the nature of things there is room for more than one, will be those which cover the essential points of theory-development, together with a wholesome amount of the descriptive and qualitative side of the subject.

Dr. Waddell has brought into the space of 278 pages a vast amount of descriptive and historical detail which are very essential to the beginner. It is a question whether he has not overdone this. At the same time, he

has kept prominently in view the quantitative basis of theory, and what is most admirable, he has given evidence of a thorough knowledge of the capacity of his students. The quantitative experiments given, although too few in number, are all perfectly possible in the hands of the average student.

The book is attractively made, well bound, and very carefully edited. There is nothing particularly new in the subject matter or treatment, although the industrial processes mentioned are brought down to date. Altogether the book is entitled to the respectful consideration of teachers.

Indianapolis. GEO. W. BENTON.

Books Received.

Victor von Richter's Text-book of Inorganic Chemistry. Edited by Prof. H. Klinger, University of Koenigsberg. Authorized translation by Edgar F. Smith, Professor of Chemistry in the University of Pennsylvania (assisted by Walter T. Taggart). Fifth American from the tenth German edition. P. Blakiston's Son & Co., Philadelphia, 1900. 430 pages. $1.75.

Victor von Richter's Organic Chemistry or Chemistry of the Carbon Compounds. Edited by Prof. R. Anschuetz, University of Bonn. Authorized translation by Edgar F. Smith, Professor of Chemistry, University of Pennsylvania. Third American from the eighth German edition. Volume I. Chemistry of the Aliphatic Series. P. Blakiston's Son & Co., Philadelphia, 1899. 625 pages. $3.00.

Victor von Richter's Organic Chemistry or Chemistry of the Carbon Compounds. Edited by Prof. R. Anschuetz, University of Bonn (assisted by Dr. G. Schroeter). Authorized translation by Edgar F. Smith, Professor of Chemistry, University of Pennsylvania. Third American from the eighth German edition. Volume II. Carbocyclic and Heteocyclic Series. P. Blakiston's Son & Co., Philadelphia, 1900. 671 pages. $3.00.

Laboratory Instructions in General Chemistry. Arranged by Ernest A. Congdon, Ph. B., F. C. S., Professor of Chemistry, Drexel Institute, Philadelphia. P. Blakiston's Son & Co., Philadelphia, 1901. 110 pages. $1.00.

A manual of Elementary Practical Physics for High Schools. By Julius Hortvet, B. S., Teacher of Physics in the East High School, Minneapolis. H. W. Wilson, Publisher, Minneapolis, 1900. xi. and 255 pages. $1.00.

A Reader in Physical Geography for Beginners. By Richard Elwood Dodge, Professor of Geography, Teachers' College, Columbus University; and Editor of the "Journal of School Geography." Longmans, Green & Co., New York, 1900. ix. and 237 pages. $0.70.

Reports of Meetings.

NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS.

The tenth regular and fourth annual meeting of the New England Association of Chemistry Teachers was held in Boston on January 26. About fifty members were present. The annual reports of the secretary, treasurer, and president, showed that the association had gained in members during the year, especially in associate membership, that there was a large balance in the treasury, and that the lines of work pursued by the association were not only increasing the interest in chemistry but were contributing directly to better and more fruitful teaching. The following officers were elected for the ensuing year: President, R. P. Williams, Boston, Mass.; vice-president, Albert C. Hale, Brooklyn, N. Y.; secretary, F. W. Howe, Framingham, Mass.; treasurer, E. F. Holden, Melrose, Mass.; executive committee, the above officers *ex officio* and H. J. Chase, Danvers, Mass.; Albert S. Perkins, Dorchester, Mass., and L. J. Manning, Medford, Mass. The constitution was so amended that "The officers shall be chosen by ballot at the third meeting of the calendar year."

The committee on a grammar school course in chemistry reported that in its judgment such a course should be adopted, if any course in science be added to the present curriculum, but the recommendation was not sustained by the association. The committee on reference books reported that a list of books in chemistry compiled primarily for the use of teachers in secondary schools was in press and would soon be ready for distribution. The committees on physical, physiological, and general chemistry read elaborate reports of the progress of the science in these branches since the last meeting. A summary of these reports will subsequently appear in the third Circular of Information which is issued at irregular intervals by the association. The committee on new apparatus presented through the courtesy of three members several ingenious laboratory devices. One was an apparatus for determining the composition of hydrochloric acid gas. It consists of a bottle of known capacity provided with an inlet and outlet tube; a small, thin glass bulb of known volume previously filled with sodium amalgam is placed in the bottle; the latter is then stoppered tightly and filled with hydrochloric acid gas as usual, and when full the tubes are plugged and the bulb broken by shaking the bottle. After the action has stopped, the bottle is opened under water and the loss in volume of the (corrected) original gas is called the chlorine. The results are very accurate. Attention was also called (1) to the efficiency of absorbent cotton in filtering, in cleaning and drying test tubes, glass tubes, and bottles; (2) to the use of

a clay pipe as a sulphur dioxide generator, the burning sulphur in the bowl being continuously supplied with air through the stem; (3) to a convenient support for a glass graduated cylinder made by setting the graduate in a base made from a tin cover filled with plaster of Paris and coated with asphalt paint, and (4) to the efficiency of hair curlers in cutting glass, the wooden handle allowing the tongs to be used when hot.

After the banquet there was a symposium on Laboratory Notes. The following topics were discussed by thirteen members: (1) Special value of laboratory notes to student and teacher. (2) Should complete notes be written in the laboratory, or no notes or very brief ones there, and fuller ones outside, and should students be allowed to take note books from the laboratory. (3) How fully ought apparatus and operations to be described, should ink or pencil be used, and should drawings be required. (4) The main points to be brought out in notes and how full ought the final notes to be. (5) Methods of examining and marking notes. (6) Subsequent discussion of laboratory notes with students.

The papers presented on these topics were carefully prepared, and were of such vital interest that their contents will be reserved for fuller treatment in subsequent numbers of School Science.

Reported by Lyman C. Newell.

Correspondence.

QUESTIONS FOR DISCUSSION.

Teachers are invited to send in questions for discussion as well as answers to the questions of others. Those of sufficient merit and interest will be published.

1. Is there not a flaw in the statement commonly made that "children are natural observers, and that later school life educates the observing powers out of them"?

2. Considered from the biological standpoint, what constitutes a "good drawing"?

Which is the better criterion by which to judge of a student's work in biology—a good drawing or a good description?

4. Given one or two hundred wires from 15 cms. to 2 ms. long, some straight, some coiled, and of gauge numbers ranging from 16 to 30 B. & S. What is the best way to keep them from getting tangled, and yet have them accessible and in a small space?

5. Suppose a class has been made somewhat familiar with the conception of electrostatic potential—what is the best way to link to this electromotive force and difference of potential in electrokinetics?

6. What minerals are suitable for "unknowns" in elementary qualitative analysis?

7. To what extent should other indicators than litmus be used in the elementary study of acids, bases and salts?

8. To what extent should the English of laboratory notes be corrected by the science teacher?

9. What experiments best show that sulphuric acid is not as "strong" an acid as hydrochloric or nitric acid?

10. What proportion ought to be given to morphology, physiology and ecology? Does either possess superior educational value?

BUREAU OF INFORMATION.

E. F. L. writes: "I have observed that when magnesium is heated in a porcelain crucible, there is often produced a small amount of a brownish black substance which forms a hard and shiny crust in the lower part of the crucible. Sometimes it sticks so tenaciously to the crucible that it cannot be removed, and it does not dissolve in any acids, not even nitro-hydrochloric. Will you kindly inform me as to the nature of this produce, how to prevent its formation, and how to remove it, when once formed"?

Ans. The substance is silicon derived from the porcelain by the reducing action of magnesium. There may also be formed compounds of silicon and magnesium, and of magnesium and nitrogen, but these are decomposed by acids. The magnesium should be heated very gently, and as free access of air as possible provided for, but even then there is no certainty that the substance may not be formed. The crucible may be cleaned fairly well by boiling it out for some time with a strong solution of caustic potash.

R. K. writes: "I teach science and German here, and would like to get hold of some good periodical in German that treats of scientific topics much as SCIENCE in this country does. Will you be so kind as to recommend to me such a journal, and also tell me how to order it"?

Ans.—Naturwissenschaftliche Rundschau, Friedr. Vieweg & Sohn in Braunschweig, publishers; 4 marks per quarter. Any good book dealer ought to be able to order it for you.

CLEARING HOUSE.

Teachers desiring to offer for exchange books, apparatus, etc., may insert a notice to that effect at the nominal rate of one cent per word, *in advance.*